NEURAL CORRELATES OF A NON-IMAGE-FORMING RESPONSE TO LIGHT EXPOSURE DURING THE DAYTIME: A FMRI STUDY

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INTRODUCTION

Neural correlates of the alerting effect of light exposure that persist during darkness have been investigated in human using positron emission tomography during the biological night (1). Here, our goal was to observe the neural correlates of such a non-image forming (NIF) response to light during the daytime (i.e. biological day) using functional magnetic resonance imaging (fMRI).

METHODS

Thirteen healthy subjects (7 females; age: 22+/-1.82; BMI: 22.2+/-2.4) followed a 7-day constant sleep schedule before being recorded twice, 2-days apart. On both days, they stayed in dim light for 3 hours (<5lux) before performing six 8-minute sessions in a 3T Allegra MR scan (Siemens, Erlangen) (32 slices, voxel size: 3.4x3.4x3mm, TR: 2130ms, TE: 40ms, FA: 90°) while they were exposed to an auditory oddball paradigm in which they had to respond to odd sounds by pressing a button and report their count. All sessions were performed in darkness (<0.01lux) except for session 3 and 4 of one day in which volunteers had one eye exposed to a bright white polychromatic light (>7000lux). Light was randomly given during the first or second day in a counterbalanced order over subjects.

Data were analysed using SPM2 (http://www.fil.ion.ucl.ac.uk/spm/spm2). At the individual level, the statistical analysis looked for a light regime (light vs darkness) by sessions (5vs2) interaction effect, i.e. the changes in brain response related to the light exposure and not accounted for by simple repetition of sessions. Individual summary statistic images were used in a random effect analysis. Inference ($p<0.05$) was corrected for multiple comparisons on small volumes of interest. The analysis focused on 6 reference areas reported to be activated during auditory oddball (2, 3), updating working memory (4), or attentional tasks (5).

RESULTS

A significant interaction was observed in the right superior temporal gyrus [44 –16 –8; Z-value = 4.18; $p_{svc} = 0.025$], the left cingulate gyrus [-20 –40 54; Z-value = 3.81; $p_{svc} = 0.033$], the superior frontal sulcus [18 6 74; Z-value = 3.53; $p_{svc} = 0.026$], the frontopolar cortex [-24 56 –2; Z-value = 3.33; $p_{svc} = 0.042$], and the right intraparietal sulcus (rIPS) [24 –56 38; Z-value = 3.62; $p_{svc} = 0.046$; blue cross hair on Figure]. Beta estimates show that the progressive decrease in activity observed in these areas when sessions are repeated in darkness (2D vs 5D, right on Insert) is counteracted by light exposure (2L vs 5L, left on Insert).

CONCLUSION

In this study we have evidenced for the first a set of brain areas associated with daytime NIF response to bright light in the context of an attentional oddball paradigm using fMRI, taking into account a potential order effect.

1. Perrin F et al. Curr Biol **14**(20): 1842-6 (2004).
2. Kiehl KA et al. Psychophysiology **38**: 133-42 (2001).
3. Stevens AA et al. Magn Reson Imaging **18**(5): 495-502 (2000).
4. Collette F et al. Hum Brain Mapping *In press* (2005).
5. Hopfinger JB et al. Nat Neurosci **3**(3): 284-91 (2000).

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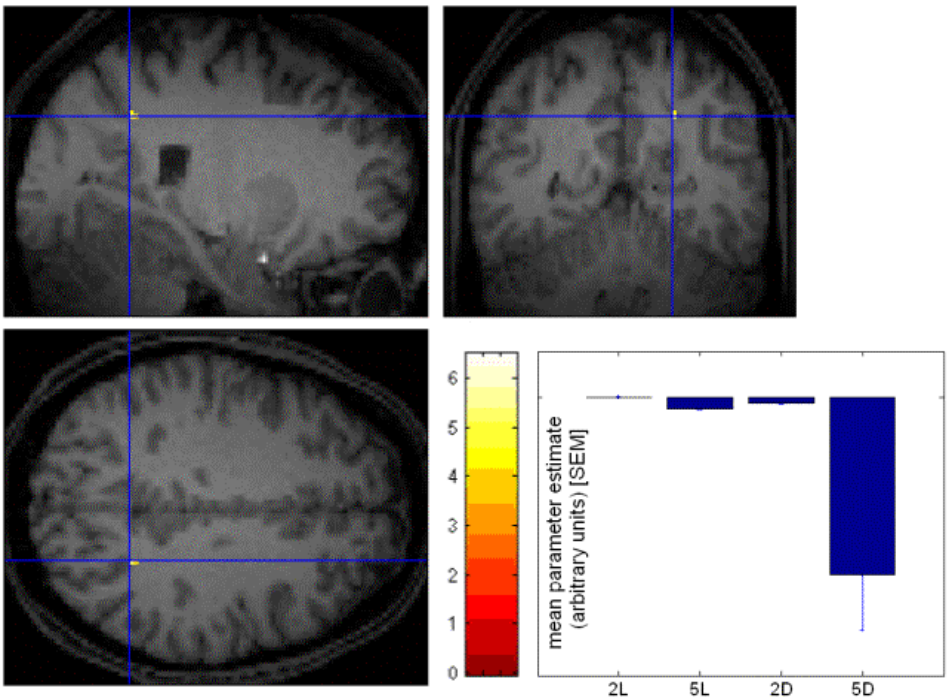

Significant light regime by session interaction effect in the rIPS, displayed over the normalized structural scan of a representative subject at $p<0.001$ uncorrected. Insert: beta estimates in the rIPS across sessions ($2\ 5_{light}$ / $2\ 5_{darkness}$).